Section: Cardiology

Original Research Article

UTILITY OF ANKLE BRACHIAL PRESSURE INDEX (ABPI) AND CAROTID INTIMA MEDIA THICKNESS (CIMT) IN PREDICTING CORONARY ARTERY DISEASE SEVERITY AMONG DIABETIC PATIENTS

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Abstract

Background: Diabetes is a major risk factor for the development of coronary artery disease (CAD), with a higher incidence of myocardial infarction in patients with DM than those without. CIMT has been demonstrated to be higher in people with diabetes and macrovascular disease. This study aims to find the relationship between Ankle Brachial Pressure Index (ABPI), Carotid Intima-Media Thickness (CIMT) and coronary artery disease among Diabetic Patients. **Materials and Methods:** This cross-sectional study was done on 262 patients with diabetes mellitus conducted in Government Chengalpattu Medical College for five months (October 2022 to February 2023). CIMT and ABPI tests correlated with the Coronary angiographic SYNTAX Score and interrogated carotid arteries using a linear-array transducer. The mean CIMT was calculated from six values and compared with normative data. Longitudinal Plaque screen scans were also performed. **Result:** Among 262 patients with diabetes, males were predominant (55%), 71% had uncontrolled diabetes, and 96 patients (36.6%) had systemic hypertension. There was a significant association between CIMT, ABPI and SYNTAX scores individually and in combination. ABPI had poor sensitivity for Severe CAD. When ABPI was combined with CIMT and done in parallel for severe CAD, the sensitivity increased to 83.7% with a specificity of 83.8%. Both ABPI and CIMT were poorly sensitive to moderate to severe CAD but were highly specific for predicting Severe and moderate to severe CAD. **Conclusion:** CIMT and ABPI done in parallel may be considered reliable parameters for predicting severe and moderate to severe coronary artery disease among diabetic patients.

INTRODUCTION

Worldwide Diabetes mellitus (DM) has reached epidemic proportions, and its prevalence is increasing.[1,2] Diabetes is a major risk factor for the development of Coronary Artery Disease (CAD), with a higher incidence of myocardial infarction in patients with DM than those without.[3,4] Compared to healthy controls, CIMT was increased in individuals with type 2 diabetes by 0.13 mm.[5] CIMT has been demonstrated to be higher in people with diabetes and macrovascular disease.[6] The ABPI measurement is now used worldwide as an easy, practical method for PAD evaluation and can be used to assess the risk of future cardiovascular events clinically. Although PAD risk factors showed gender differences, previous studies have recognized that patients with arterial disease of the lower extremities are at higher risk for adverse cardiovascular events, stroke, transient ischemic accident and preclinical carotid plaque.[7-9]

The American Heart Association Prevention Conference V described the ABPI as a strong and independent risk factor for cardiovascular mortality. It recommended that it can be used to detect subclinical disease in preventing cardiovascular mortality and stroke. Carotid artery disease is a manifestation of atherosclerosis and is very often present concurrently with coronary artery disease (CAD) and peripheral artery disease.[10] This study aimed to find the relationship between the Severity of CAD and increased CIMT or abnormal ABPI among diabetic patients.

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MATERIALS AND METHODS

This cross-sectional study was done on 262 patients with diabetes mellitus conducted in Government Chengalpattu Medical College for five months (October 2022 to February 2023). Ethical Committee approval and informed consent were obtained before the study started.

Inclusion Criteria

All diabetic patients undergoing Coronary angiogram (CAG) in the hospital were included.

Exclusion Criteria

Patients with Vasculitis, Vascular malformations, Malignancy, Chronic Kidney disease and patients unwilling to CAG were excluded.

CIMT and ABPI tests were done and correlated with the corresponding Coronary angiographic SYNTAX Score. The carotid arteries were interrogated with a linear-array transducer operating at a fundamental frequency of 7 MHz. As per the consensus statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force,[11] only Distal 1 cm of the far wall of each Common Carotid Artery (CCA) was obtained and compared with values from a normative data set.[12]

After optimizing the image, a cine-loop with 3–5 beats was stored. The CCA was then imaged from two additional complimentary angles, approximately 45° anterior and posterior to the first image. A cine-loop was stored for each view on the right and left sides. The average of the six values was taken as the mean CIMT and compared with the normative data set by Kasliwal RR et al,[12] Longitudinal Plaque screen scans (3-5 beat cine loop from at least three different angles in each segment) at near and far walls of CCA, Bulb and Internal carotid artery segments were also done according to the task force recommendation. The presence of carotid plaque or CIMT greater than or equal to the 75th percentile for the patient's age, sex, and race/ethnicity are indicative of increased CVD risk and are considered high.[11]

Measurement of ABPI was made after ten minutes of rest. A pneumatic cuff was placed around the ankle 3 cm above the medial malleolus using an appropriate size. The pressure was measured at the dorsalis pedis and posterior tibial arteries using a hand-held continuous sine wave Doppler probe (5-10 MHz). Pressure was recorded from both arms using an appropriate-size cuff. ABPI was calculated by dividing the lower limb's higher systolic blood pressure value by that of the upper limb. Literature studies concluded that an ABI value of 0.9 or less is 100% sensitive and 95% specific to PAD[13] and was taken as an abnormal ABPI in the present study. SYNTAX score was applied to the angiographic study of all patients, and they were classified based on risk. SYNTAX score< 22 was considered low risk and Mild CAD. A score of 23-32 was considered moderate CAD, and a SYNTAX score of more than 32 was considered high-risk and severe CAD.

A single observer did CIMT and ABPI measurements to eliminate bias, and these two tests were done in parallel. CIMT, ABPI measurements, Angiographic SYNTAX Scores and other parameters were entered in Microsoft Excel. Appropriate tests of significance were done.

RESULTS

262 Diabetic patients undergoing Coronary angiogram in the hospital were assessed by CIMT and ABPI and correlated. All patients were on oral hypoglycemic agents. The mean age was 57 $\pm$ 9.3 years. Of 262 patients, 144 were males (55%), and 118 were females (45%). 71% (N= 186) had uncontrolled diabetes. Ninety-six patients had systemic hypertension along with DM, 103 patients were smokers, and 88 were alcoholics. 55 Patients had severe CAD as indicated by a SYNTAX score > 32, 116 patients with moderate CAD (SYNTAX Score 23-32) and 91 with a Score <22.

40 Patients (15.2%) had abnormal ABPI, out of which 20 patients had severe CAD (SYNTAX > 32). The sensitivity of ABPI in predicting Severe CAD is 36.36% (95% CI 23.8-50.4%), and specificity is 90.34% (95% CI 85.47-94%) with an accuracy of 79%. Positive (PLR) and Negative (NLR) Likelihood Ratios were 3.76 and 0.7 respectively. Positive Predictive Value (PPV) was 50% and Negative Predictive Value (NPV) was 84.23%. In terms of predicting moderate and severe CAD (SYNTAX > 22), ABPI is 21.64% (15.7- 28.5%) sensitive and 96.7% (90.6- 99.3) specific with an accuracy of 47.71%, PLR- 6.56, NLR-0.8, PPV-92.5% and NPV 39.6%.

The chi-square test was done separately between abnormal ABPI and Syntax> 32 and abnormal ABPI and Syntax> 22 (moderate to severe CAD). Both were statistically significant ($p < .001$). Receiver operator characteristics Curve of ABPI for severe CAD and Moderate to severe CAD were plotted. Area Under ROC for Severe CAD was 0.81 (0.75-0.87) with a Youden's J cut–off point of 1.04, which had 83.6% sensitivity and 74% specificity. The AUC for Moderate to Severe CAD was 0.79, with Youden's J cut-off point 1.08, with sensitivity and specificity of 87.6% and 61%, respectively.

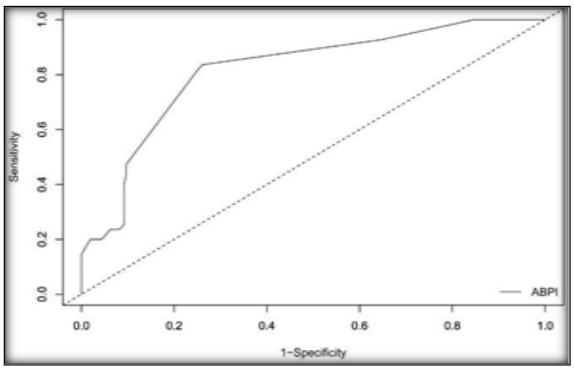

Figure 1. ROC Curve of ABPI for Severe CAD

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Table 1: SYNTAX Score and ABPI

	SYNTAX <22	SYNTAX 23-32	SYNTAX >32	Total
Abnormal ABPI	3	17	20	40
Normal ABPI	88	99	35	222
Total	91	116	55	262

Table 2: SYNTAX Score and CIMT

	SYNTAX <22	SYNTAX 23-32	SYNTAX >32	Total
Increased CIMT	2	13	40	55
Normal CIMT	89	103	15	207
Total	91	116	55	262

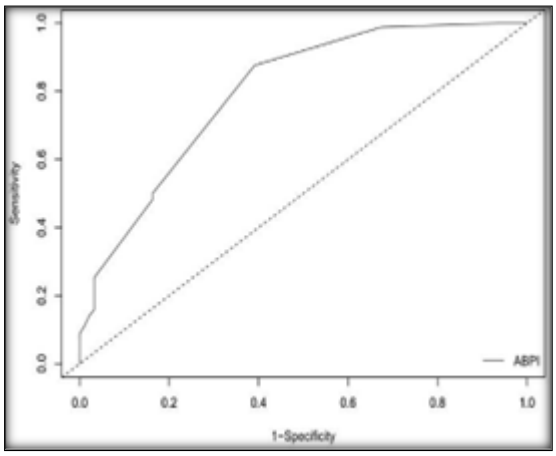

Figure 2: ROC Curve of ABPI for Moderate/Severe CAD

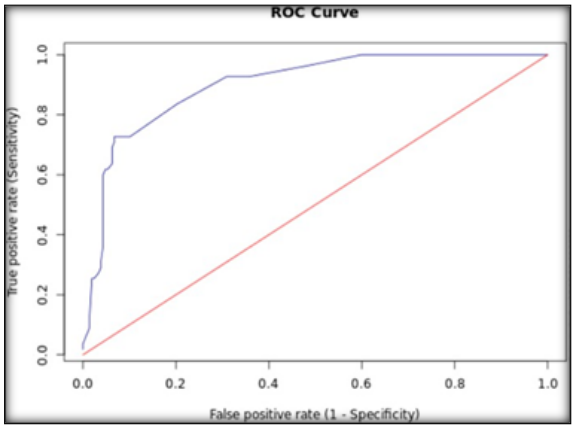

Figure 3: ROC Curve of CIMT for Severe

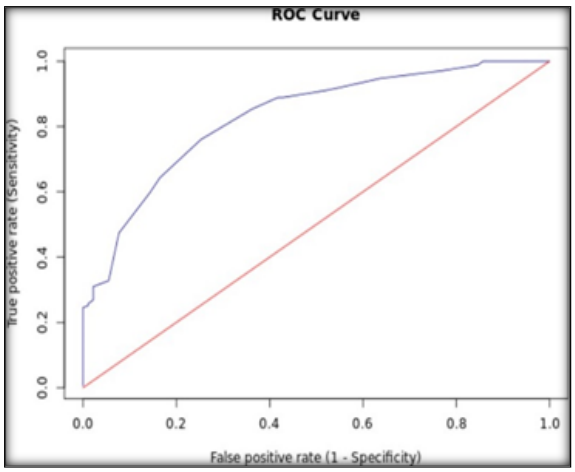

Figure 4: ROC Curve of CIMT for Moderate/Severe CAD

55 Patients (20.9%) had increased CIMT, out of which 40 patients had severe CAD (SYNTAX > 32). The sensitivity of CIMT in predicting Severe CAD is 72.7% (95% CI 59.04- 83.86%), and specificity is 92.75% (95% CI 88.3-95.3%) with an accuracy of 88.55%. Positive (PLR) and negative likelihood ratio (NLR) are 10.04 and 0.29, respectively. Positive (PPV) and negative predictive values (NPV) are 72.73% and 92.75% respectively. In terms of predicting moderate and severe CAD (SYNTAX > 22), CIMT is 30.9% (95% CI 24.1- 38.5%) sensitive and 97.8% (95%CI 92.3- 99.7) specific with an accuracy of 54.2%. PLR and NLR were 14.1 and 0.7, respectively. PPV was 96.36% and NPV was 43%. A chi-square test of independence was performed to examine the relation between increased CIMT and severe CAD. The relationship between these two variables was statistically significant, X2= 112.3 (p <0.001). Receiver operator characteristics Curve of CIMT for Severe CAD and Moderate to severe CAD were plotted. Area Under ROC for Severe CAD was 0.9 with a Youden's J cut–off point of 0.78, which had 72.7% sensitivity and 93% specificity. AUC for Moderate and Severe CAD was 0.83 with a Youden's J cut point- 0.65 had sensitivity and specificity of 76% and 74%, respectively.

The two tests were done in parallel, and the results were interpreted using the OR rule. i.e., yields a positive diagnosis if either test is positive. Combined sensitivity and specificity were calculated for CIMT, and ABPI which was 82.7%, with a combined specificity of 83.8%. When the two tests were combined for Moderate to Severe CAD (i.e., Syntax > 22), it was 45.8% sensitive and 94.6% specific.

DISCUSSION

The present study was conducted to find the usefulness of CIMT and ABPI in predicting Severe CAD and Moderate to Severe CAD (Syntax >22). 262 Diabetic patients undergoing coronary angiogram were stratified according to Syntax score and correlated with their corresponding CIMT and ABPI values. Males were predominant among them; 71% of patients had uncontrolled diabetes, and 55 patients had severe CAD.

The study by Xu L et al,[14] demonstrated that the risk of CAD doubled with ABPI < 0.9 in patients with diabetes mellitus. In a study by Manvi Sharma et al,[15] done in patients with diabetes mellitus, ABPI

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had a sensitivity of 84.5% and specificity of 90.5% in predicting CAD. In our study, ABPI value less than 0.9 had a poor sensitivity in predicting Severe CAD but was highly specific with a good NPV. ABPI <0.9 is also poorly sensitive for Moderate and Severe but has good PPV.

In a study by Chang et al,[16] ABPI values of less than 0.9 had a poor sensitivity in predicting CAD with high specificity and PPV, illustrating that it is important for physicians to pay attention to patients with low ABPI values who are at substantial risk for CAD. Abnormal ABPI (ABPI <0.9) was statistically significant ($p < .001$) for both severe CAD and moderate to severe CAD. Diabetic patients with abnormal ABPI are more likely to have severe CAD and moderate to severe CAD.

The ROC curve was plotted after calculating ABPI in all subjects, and it plots the true positive rate in predicting the severity of CAD against the false positive rate. There was a good Area Under ROC for Severe CAD (0.81) and Moderate to severe CAD (0.79) as against AUC 0.89 in a study by Sharma M.[15] At a cut-off point of 0.97 and AU ROC 0.89 it was 84.5% sensitive and 90.5 specific for CAD in diabetic patients. Forty patients with increased CIMT had SYNTAX scores>32. CIMT's correlation with the incidence and severity of lesions in the other arterial sites is modest, especially when only CIMT-CCA is reported.[17-19] In a large meta-analysis, which included 22 studies, the diagnostic sensitivity and specificity of CIMT for CAD were 68% and 70%, respectively.[20]

However, in this study, the sensitivity of increased CIMT for severe CAD and Moderate to severe CAD (Syntax >22) were derived separately instead of considering whole CAD. Increased CIMT is 72.7% sensitive for severe CAD, whereas sensitivity is low (30.9%) for moderate to severe CAD. On the other hand, Increased CIMT is highly specific for both severe CAD (92.7%) and Moderate to Severe CAD (97.8%). Diabetic patients with increased CIMT are more likely to have severe CAD than patients with Normal CIMT, as evidenced by the significant p-value ($p < .001$). Increased CIMT is statistically significant ($p < .001$) in predicting moderate to severe CAD (SYNTAX >22).

The area under the ROC curve (AUROC) between CIMT and coronary artery disease was 0.648 (P=0.0001), and the CIMT of 1 mm or more was associated with the presence of coronary artery disease with a specificity of 90.5%.[21] When the two tests were combined and done in parallel, they had poor sensitivity for Moderate to severe CAD. In contrast, the combined Sensitivity and specificity of CIMT and ABPI for severe CAD were 82.7% and 83.8%, respectively. Both of these were good values to justify the combined clinical utility of two tests to be done in parallel for predicting severe CAD (SYNTAX >32) in diabetic patients.

CONCLUSION

CIMT and ABPI tests are reliable parameters for predicting severe and moderate to severe CAD in diabetic patients. CIMT is the most sensitive test for predicting severe CAD, and ABPI has improved sensitivity when combined with CIMT. The ease of use and non-invasive nature of these tests make them well-suited for use in diabetic patients to assess their atherosclerotic burden.

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